Performing the Rolls Royce Trent XWB Non-Modification Service Bulletin 72-AL055 at Finnair Technical Services

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Abstract

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Abstract

This thesis clarifies the process of performing the Rolls Royce NMSB 72-AL055 according to the on-wing methods for the Airbus A350-900 aircraft equipped with Rolls Royce Trent XWB-84 engines. It focuses on how the NMSB can be completed with tools already available at Finnair Technical Services and tries to find the best practices for them.

Both on-wing methods listed in the NMSB were tested in the practice. This thesis gives tool selection tips for the method A borescope inspection and points out the best practices for successful completion. For the method B data quantity verification, a digital tool was created by using Microsoft's Power Query and Excel to speed up and automate the data handling process. A step-by-step guide was created for its use, which is included as an appendix in this thesis.

The NMSB was found to be performable by either of the on-wing methods. However, the data quantity verification should be the first choice if all the conditions for its completion are met. It can bring large time savings since it can be performed to the whole fleet simultaneously and it can be attempted without risk of additional delays or expenses since it does not need physical maintenance activities to be performed for the aircraft. Borescope inspection was found to be risky due to high skill requirements and possible damage to the overtemperature probe when getting access to the borescope hole. However, with proper preparations and the suggestions presented in this thesis, the inspection can also be performed smoothly.

Keywords

72-AL055, Trent XWB, service bulletin, aircraft, borescope, Excel, Power Query

Contents

Abbreviations

• AD	Airworthiness Directive
• AFDX	Avionics Full Duplex Switched Ethernet
• AMM	Aircraft Maintenance Manual
• ARP	Anti-Rotation Plate
• BSI	Borescope Inspection
• CDS	Control and Display System
• EASA	European Aviation Safety Agency
• EEC	Electronic Engine Controller
• EFC	Engine Flight Cycles
• EHM	Engine Health Monitoring
• EMU	Engine Monitoring Unit
• HP	High Pressure
• HPC	High-Pressure Compressor
• HPT	High-Pressure Turbine
• MSB	Mandatory Service Bulletin
• NMSB	Non-Modification Service Bulletin
• Off-Wing	Component which is removed from the airframe
• On-Wing	Component which is installed to the airframe
• SB	Service Bulletin
• TLM	Time Limits Manual
• Traficom	Finnish Transport and Communications Agency

1 Introduction

1.1 Important Information About This Thesis

The information in this thesis and its appendix shall be used for research purposes only and none of the contents should be used as maintenance instructions. The latest revision of the relevant aircraft and equipment manufacturer's manuals must always be followed and none of the information in this thesis or its appendix replaces or adds any information to their contents. None of the information in this thesis or its appendix is updated and should be treated as potentially outdated.

1.2 Background

On 28 March 2024, Rolls Royce plc published the NMSB 72-AL055, which concerns the possible release of the HPT anti-rotation plates on its Trent XWB series engines installed on Airbus A350-900 aircraft. Trent XWB engine includes 14 anti-rotation plates on the HPT to HPC connection joint, which the NMSB is affecting. Rolls Royce has found the anti-rotation plates to be released in a total of five engines which all have done a shop visit where the HPT to HPC connection joint was disturbed (Rolls Royce plc 2024b). The HPC anti-rotation plates are used during the engine assembly to keep the HPT to HPC connection bolts from rotating in a constrained space when their nuts are tightened. They do not have a function during engine operation but can cause damage if become loose inside the engine (Rolls Royce plc 2024a). The NMSB gives two possible on-wing completion methods for the operator. The method A on which the ARPs are inspected by using a borescope camera and the method B on which the integrity of the ARPs is confirmed by using engine vibration data.

The client for this thesis was Finnair Technical Services. A request was to investigate how feasible the in-house completion of the on-wing completion methods are and to find the best practices for them. A request was also made to create a tool that can make the method B data quantity verification easier. Handling the data manually without automated tools would be difficult and take a large amount of time, especially when the NMSB must be completed for the whole fleet. Finnair's fleet includes currently 17 A350 aircraft and in addition, two more are going to be delivered in the future. Finnair Technical Services performs most of the line maintenance activities in-house, which would also include most of the times the NMSB in question. Heavier maintenance such as engine shop visits for which an engine must be removed are contracted elsewhere, during which completion of the NMSB is also possible.

1.3 Service Bulletins

A service bulletin is a letter from the aircraft or component manufacturer to equipment operators and maintenance organizations. It includes information that the manufacturer intends to be used as an addition together with equipment maintenance manuals and a planned maintenance program. It contains additional information concerning operations or maintenance of the equipment. Service Bulletins often contain modification instructions that can alter or improve the equipment. Completion of service bulletins must be recorded into equipment maintenance logs. Service bulletins containing inspections can be named as non-modification service bulletins because it does not alter the equipment but can contain for example additional inspections. When a service bulletin permanently alters the equipment physically or changes its operational characteristics, completed service bulletins are recorded into a modification status of the equipment. When the modification is performed into a component, the performed modification will be also marked into the component's information tag or written on its surface. This can also change the part number of the component if the service bulletin calls to do so, which can then also change the component's compatibility status in the parts catalogues.

1.4 Mandatory Completion

In Europe, EASA functions as the main authority in civilian aviation. EASA follows the regulations created by the European Union and prepares them to be implemented by national-level institutions, which in Finland is Traficom.

Aircraft type certificate holders can issue Service Bulletins to their equipment if they see features in the aircraft or in its maintenance program that can be improved or require additional attention. If EASA sees that the subject of the SB affects flight safety, it can cover it under an airworthiness directive and make performing of the SB mandatory. This differs from MSBs, which is a type certificate holder's designation and is separate from ADs which can make the SB mandatory despite it being called SB or MSB. (EASA 2024.) At the time of writing this, no AD has been published about the NMSB.

The NMSB is however listed in the engine Time Limits Manual in the chapter 05-20-01 Airworthiness Limitations (Mandatory Inspections) which has been approved by EASA and is equally mandatory as AD would be. All changes to the manual must also be approved by EASA. For the inspection TLM states to refer to the NMSB 72-AL055 and that the inspection interval is 700 EFC. An engine flight cycle starts when the engine is started before take-off and ends at a shutdown after the landing. Other ground running of the engine does not increase the EFC count, such as maintenance ground runs and aborted take-offs. During the flight, only one EFC is counted despite of touch-and-go operations or in-flight shutdowns. Different rules apply for certain engine components if the aircraft is used for pilot training, which does not however affect EFC calculation for the MNSB interval. (Rolls Royce plc 2023.)

The specific 700 EFC NMSB completion interval is likely coming from the combination of assessed effects and the likeliness of failure. This is a common method for assessing risks and determining what kind of actions are required to mitigate them.

1.5 Rolls Royce Trent XWB Engine

Trent XWB is a high-bypass turbofan engine designed for widebody aircraft that is currently only being used in Airbus A350. It has two variants in use, XWB-84 with 84000 lb of thrust, which is used in Airbus A350-900, and XWB-97 with 97000 lb of thrust, which is used in A350-1000 and A350F freighter. (Rolls Royce plc 2024f)

The engine consists of three spools. A low-pressure spool which is powered by turbine stages 4 – 9 and it is powering the fan. An intermediate-pressure spool is powered by the turbine stages 2 and 3 and it is powering the compressor stages 1 – 8. A high-pressure spool which is powered by a stage 1 turbine powers the compressor stages 9 – 14. Viewed from the rear low-pressure and intermediate-pressure spools are rotating anticlockwise and the high-pressure spool rotating clockwise. The combustion system consists of an annular combustion chamber, where the fuel is injected and ignited with fuel nozzles, and a high-energy ignition system. The engine is lubricated by self-contained lubrication systems, where oil is circulated from the oil tank to bearings and gears and then back to the tank. Airflow through the engine is divided into cold by-pass flow, which is only propelled by the fan, and hot flow through the engine core, where air is used for the combustion and cooling of components. Expansion of the core flow air after the combustion propels the turbine stages from where power is transferred through the spools for the compressor stages and the fan. Power is also transferred from the high-pressure shaft to the external gearbox for the fuel, oil and hydraulic pumps, variable frequency generators and to the dedicated alternator. Also, the air-starter motor is located in the external gearbox, which rotates the high-pressure spool with the power of bleed air during an engine start. (Rolls Royce plc 2023.)

A view of the engine internals is shown in Figure 1. Leftmost and the largest section is the fan and the fan casing, with the guide vanes behind the fan blades and the auxiliary gearbox mounted under the casing. The narrower section starting aft of the fan blades is the core engine. In the core engine all the blades before the combustion chamber, which is shown as red, are the compressor stages. Likewise, all the blades after it are the turbine stages.

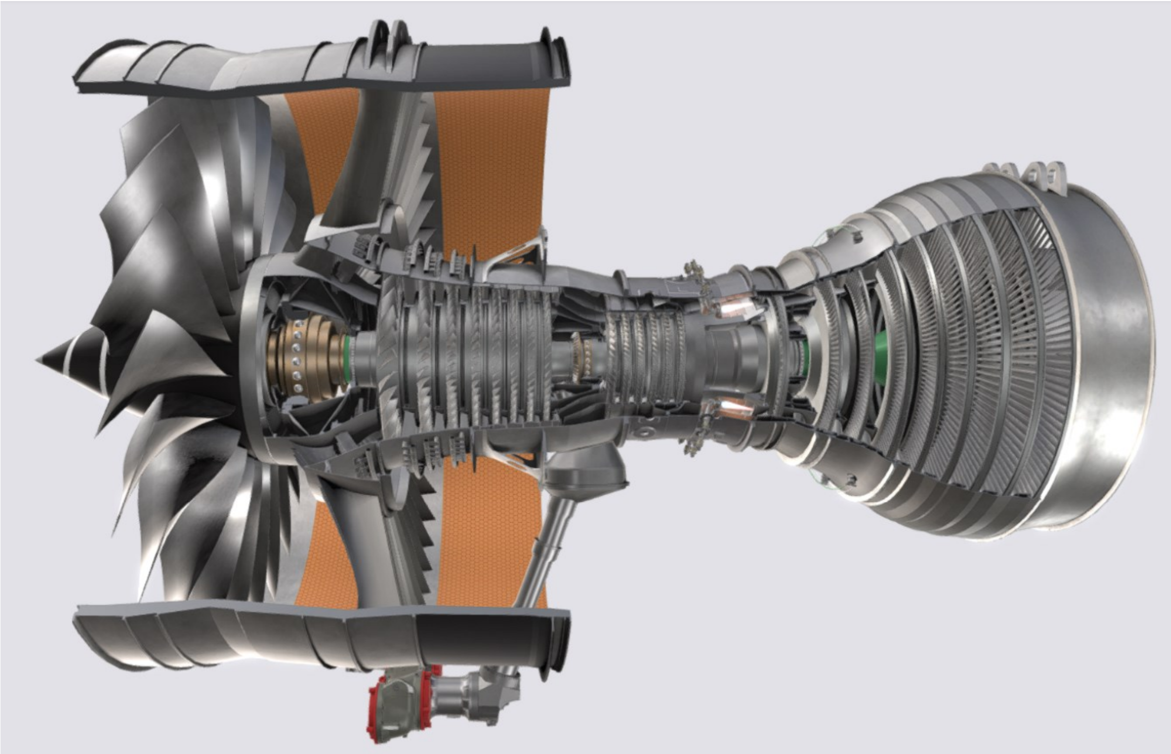

Figure 1. Trent XWB Engine (Rolls Royce plc)

2 Assessment of the NMSB

2.1 Failure of the anti-rotation plates

In the documentation, Rolls Royce does not specify what has been the failure mode of the detached anti-rotation plates. They are fastened by using a 0.25" countersunk screw and a 12-point nut with the nut being on the same side as the anti-rotation plate (Rolls Royce plc 2024d). Since the picture of the detached anti-rotation plate included in the NMSB does not have fasteners anymore present, in the most likely case the fasteners have failed. Even when the anti-rotation plates do not have a function during engine operation, failure of its fastener can cause three parts to be loose inside the engine and cause impact damage and unbalance. A borescope photograph of the anti-rotation plate, that was taken during the trial is shown in Figure 2.

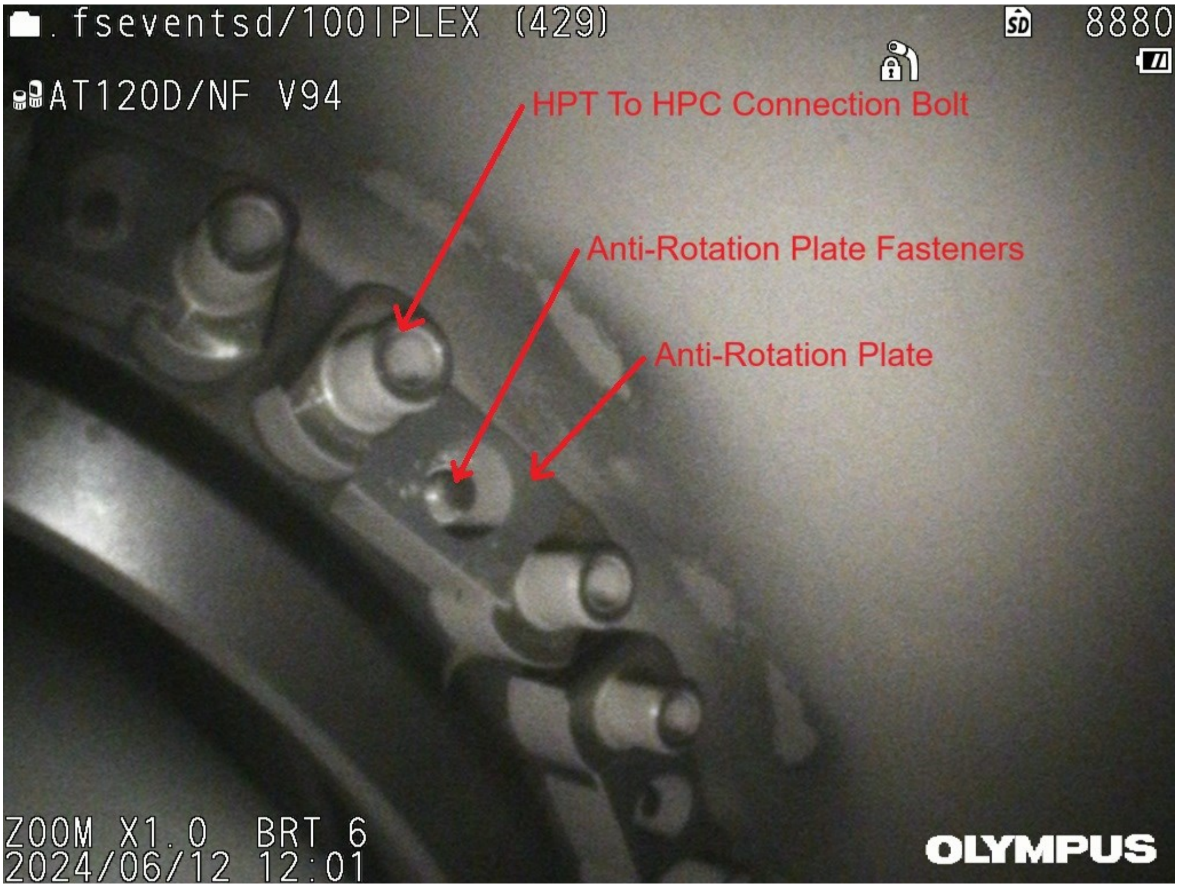

Figure 2. Borescope Photograph of the Anti-Rotation Plate

After the publication of the NMSB, Rolls Royce updated the installation procedure of anti-rotation plates by adding a step where freedom of movement of the HPT to HPC connection bolts is tested after installation of the anti-rotation plates. The HPT to HPC connection bolts must be free to rotate about five degrees. This is most likely because if an anti-rotation plate would bind the HPT to the HPC connection bolt, additional stresses would be caused to the hardware after torquing of the bolts and would potentially cause failure of the smaller anti-rotation plate screws. The manual also got a part where lubrication of the anti-rotation plate screws is prohibited. However, the HPT to HPC bolts must be lubricated with engine oil. One possible reason for this is to preserve friction on the anti-rotation plate, so it would not move so easily and come undone. For the HPT to HPC connection bolt oil however is beneficial for decreasing running torque during torquing, to allow proper bolt seating, and to prevent corrosion. An assembly drawing, which displays the anti-rotation plate and its relation to the surrounding parts is shown in Figure 3.

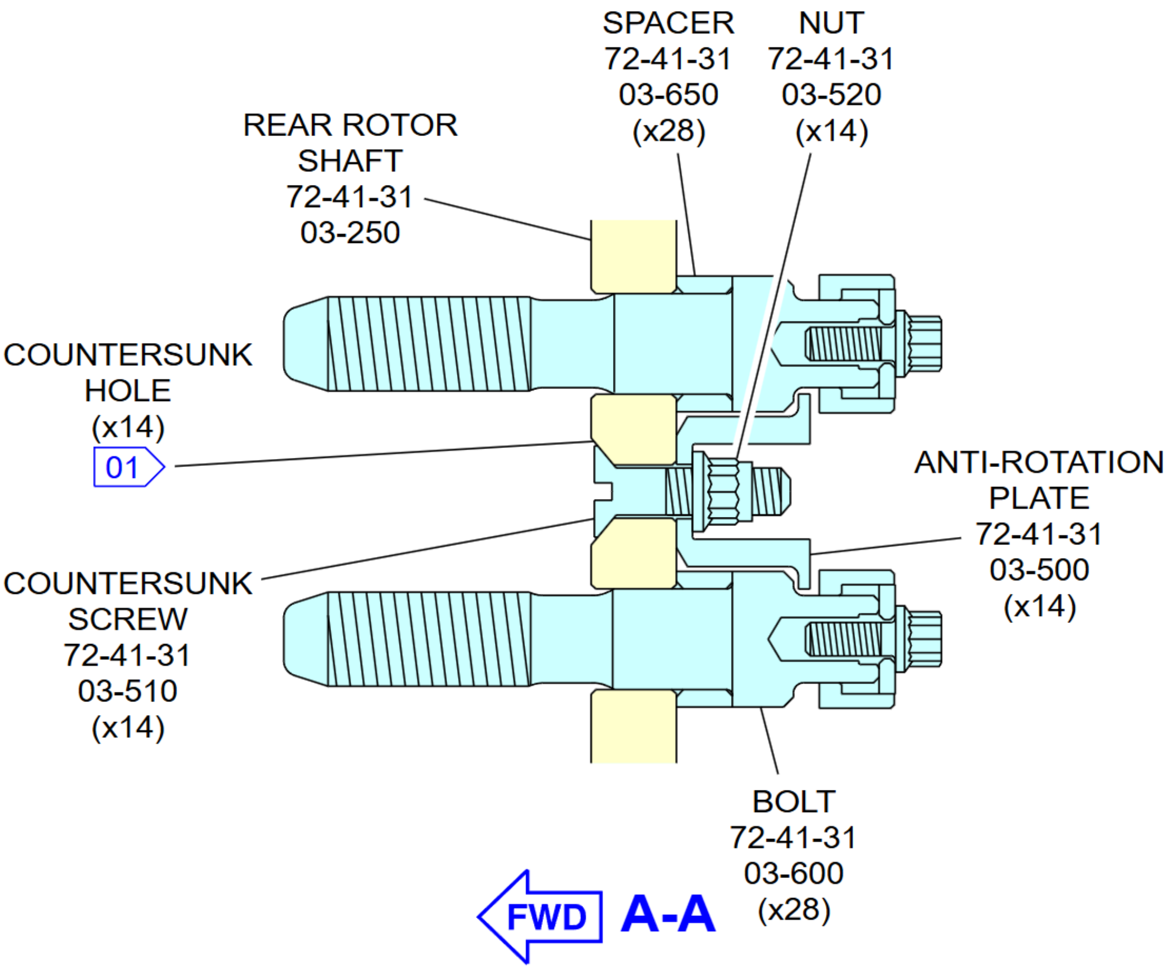

Figure 3. Anti-Rotation Plate Assembly (Rolls Royce plc 2024e)

Generally, in bolt and nut fastening methods failure can be caused by either of the two parts. Failure of a nut in aircraft systems is commonly a combination of its wear and operating conditions. In places where usage of locking wire, cable or tab washers is not feasible like in this case, the nut's holding capability relies solely on its friction. For that reason, nuts are often squished slightly oval or bent from cut tabs to increase friction. Every time a nut is installed and removed, that holding capability decreases. At the point when the difference for a new one is noticeable, the nut should be replaced. If nuts with too much wear are used, vibration and movement caused by the operating conditions can lead to the loosening of the nut and the failure of the part it is fastening. Failure of the bolt on the other hand is caused commonly by improper installation and environmental factors like stresses, corrosivity and temperature. Especially usage of the specified fastening torque during installation is crucial since incorrect torque will cause additional stresses to the bolt, which can lead to failure.

2.2 Possible Actions

The NMSB gives two on-wing methods for the completion. In the method A, the location must be inspected by using borescope equipment to visually confirm that the anti-rotation plates are intact. In method B the presence of the anti-rotation plates is confirmed by using engine health monitoring data. Rolls Royce provides the lists of transmitted End of Flight Reports and Cruise Reports on their engine health monitoring site, which are used for confirming, that there is enough data for the completion. (Rolls Royce plc 2024a.)

The method A is labour-intensive and requires specialized borescope equipment. The rear IP turbine temperature thermocouple must be removed from the top of the engine and the borescope to be inserted into its hole. The inspection is more advanced than most borescope inspections and requires more knowledge of the equipment. The NMSB advises to reserve four hours for the inspection. This was found to be possible during the trials, but most likely going to take longer for someone who has not performed it before. There is also a risk of damaging the equipment if a borescope gets stuck or the temperature probe is bent during its removal.

If conditions are met for the method B, it is the preferred method since it does not require maintenance actions to the aircraft and can be completed solely on a computer. This method requires the operator to be subscribed to the Rolls Royce EHM services, which gives access to the required report summaries on the Rolls Royce EHM website. The NMSB gives an option to complete the method B with Cruise Reports or Flight Summary-Short Reports. There must be at least 15 transmittals of either type from the last 30 flights of the engine. 15 transmittals must be a single type, so both types cannot be combined to reach the amount. Transmittals do not need to be from consecutive flights. In addition, there must be no open EHM HP vibration alerts or ARP alerts. (Rolls Royce plc 2024a)

The Method B does not require manpower from the production, but about one hour of time is needed from an engineer who has previous experience with the process. If the method B is performed by an engineer without previous experience, it is good to reserve at least three hours to learn all the required systems.

The NMSB also gives two options for it to be performed off-wing. In that case, the Method is selected according to the workscope level of the shop visit. The workscope level is stated in the Engine Management Plan. The workscope level tells the amount of disassembly required to perform necessary inspections in the specific modules. If the engine goes to a shop visit where the module 41 workscope level is 2 or above, the engine will be disassembled enough to get access to the anti-rotation plates for visual confirmation. If the module 41 workscope level is 1, the anti-rotation plates will be inspected with a borescope as in the on-wing method A, but with the engine removed from the aircraft. (Rolls Royce plc 2024a)

If any anti-rotation plates are found missing, the engine must be immediately rejected with no fly-on allowed to move the aircraft to another location. In this case, the engine must be removed from the wing if still installed and sent to a repair facility. (Rolls Royce plc 2024a)

A flowchart was created to clarify the whole NMSB completion process (Figure 1). It guides through the NMSB steps and shows the next step according to the results or the decisions taken.

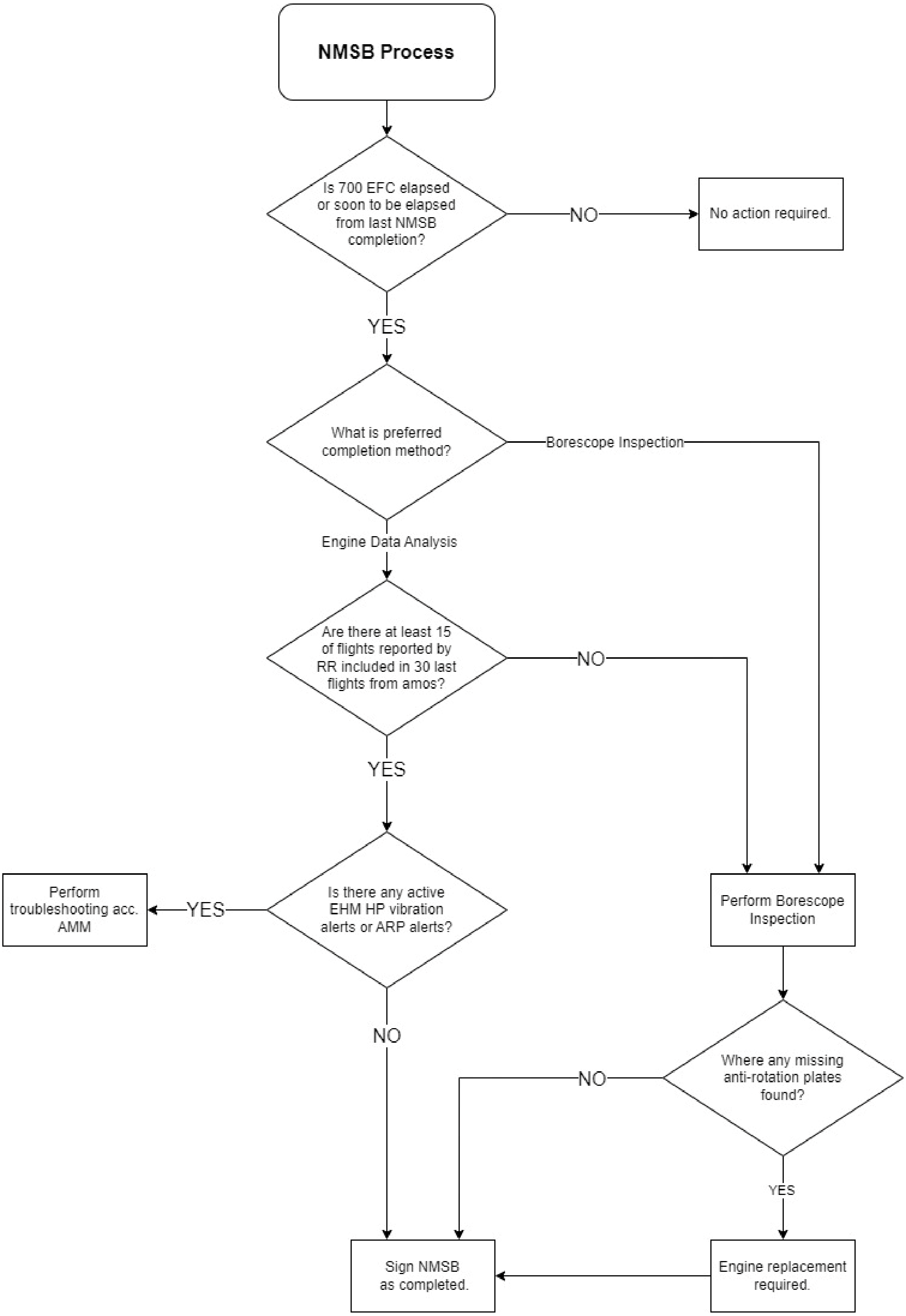

Figure 4. NMSB Completion Process

3 Performing the compliance methods

3.1 Data Quantity Verification

3.1.1 Verification Tool

As the data that is used for the completion of the NMSB according to method B is available in XLS and CSV table format, a tool was needed that can compare the report tables from the engine health monitoring website to the flight log table from AMOS. When considering different digital tools for the required job, the main questions that should be answered are:

- How often tool will be used?
- What is the user skill level?
- How much time and money are needed for the development and setup?

At Finnair, there are currently 34 engines and the possible spare engines that require the NMSB to be completed approximately once per year with the normal flight schedules, tools that require a significant amount of time and resources are not feasible solutions when there is no need for it daily. The tool would be used solely by engineers, from which better than average computer usage skills can be expected. Finnair has already subscription to Microsoft services, which includes Excel and Power Query. Excel as the most common table editing tool can be used together with Power Query, which has many more advanced data processing features that make the process further automated than with Excel alone. This combination was chosen for the task as it is the most feasible solution when taking the above-mentioned questions into account.

When making the tool, the validity of the results and the ability to verify them by the user were taken as the most important aspects. Automation was added when platform features allowed it. The tool included Excel macros to make selecting files and using Excel easier, but it was later found out that Finnair’s computers would not allow to use them for security reasons, so those features were removed. When the tool is opened, on the Setup page user must first select the data files in CSV format (Figure 5). It was decided to support only CSV format since it seemed to be handled more reliably by the Power Query than XLS files. Also, the usage of only one file type is a better option when the validity of the results is crucial since variables that might occur from the usage of multiple file types are eliminated.

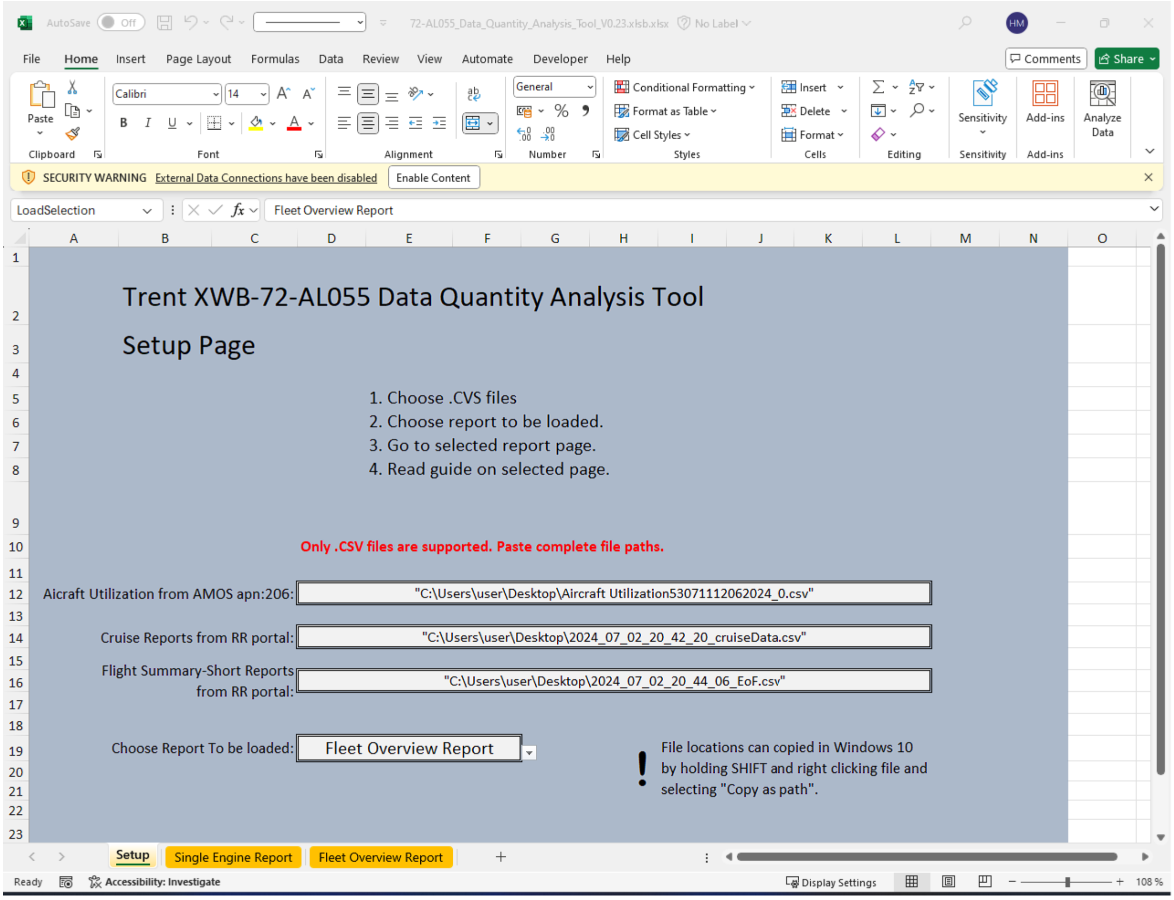

Figure 5. Setup Page

Single Engine Report

Single Engine Report generates a printable A4 size report that has separate rows for the last 30 flights of the aircraft (Figure 6). At the top of the report, the user must select the engine serial number, aircraft registration and engine position combination from a dropdown list. Combinations are automatically queried from the aircraft utilization file when the report is refreshed. Using the combination of aircraft registration and engine position on top of the engine serial numbers ensures that engine replacements will not result in falsely positive results. It is possible that in these cases results of the report are worse than in reality. This method however removes the possibility of the results being falsely deemed as satisfactory. The user then selects the date from which onward utilization data is being cut off. This allows to make the report subsequently if the engine has been removed and not yet flown 30 FC after possible installation. In this case, flights flown after the date must be subtracted from the 700 EFC limit. It is also possible to try manually find the missing data if it is known that the engine has been only lately installed. Rows on the report include the following information about the flight: flight number, route, departure time and arrival time. Next to the flight information, there are columns for the matching reports. If the report match is found, cells display the time of the matching report. If no reports are found cells display *NOT FOUND* text. This way the results of the report can be verified manually from the report data if the user sees it necessary. This was a necessary feature because it gives the engineer completing the NMSB transparent information about what the results from the tool are based on. At the bottom of the rows is displayed how many of each report type were found. The bottom of the report also includes a place for the engineer's name and date that can be filled if it is required for archiving purposes.

5.Refresh report by selecting "Refresh All" from "Data" -tab.
6. Select engine to examined.
7. Select Date of last flight to be examined. Most often date of today is to be selected unless, report will be made subsequently.
8. Refresh report by selecting *"Refresh All" from "Data" -tab.*
9. Make sure that all queries have been successfully loaded by opening "Data" -> "Queries & connections" before using any results.

Select Engine: [redacted] OH-LWG; E#1

Select Date of Last Flight: 11.6.2024

DD.MM.YYYY

Trent XWB-72-AL055 Single Engine Data Quantity Report

Engine Serial Number: [redacted]
Aircraft Registration: **OH-LWG**
Engine Position: **#1**

This Report is to be used when performing Rolls Royce NMSB Trent XWB-72-AL055 according to compliance method B.

Last 30 Flights of aircraft. (Flights when departure airport ≠ arrival airport)					Matching Reports	
Seq.	Flight Number	Route	Departure Time	Arrival Time	Cruise Report	Flight Summary-Short
1	AY1338	LHR - HEL	11.6.2024 17.39.00	11.6.2024 19.54.00	NOT FOUND	11.6.2024 19.59.19
2	AY1337	HEL - LHR	11.6.2024 13.12.00	11.6.2024 15.35.00	11.6.2024 14.20.42	NOT FOUND
3	AY122	DEL - HEL	11.6.2024 2.38.00	11.6.2024 10.49.00	11.6.2024 9.22.59	11.6.2024 10.55.30
4	AY121	HEL - DEL	10.6.2024 15.46.00	10.6.2024 23.32.00	10.6.2024 23.03.15	NOT FOUND
5	AY142	BKK - HEL	10.6.2024 0.35.00	10.6.2024 11.48.00	10.6.2024 10.56.03	NOT FOUND
6	AY141	HEL - BKK	9.6.2024 11.25.00	9.6.2024 22.14.00	9.6.2024 21.43.35	9.6.2024 22.19.15
7	AY20	DFW - HEL	8.6.2024 22.09.00	9.6.2024 7.20.00	9.6.2024 5.17.39	NOT FOUND
8	AY19	HEL - DFW	8.6.2024 9.56.00	8.6.2024 19.37.00	8.6.2024 16.06.20	8.6.2024 19.44.49
9	AY20	DFW - HEL	7.6.2024 22.16.00	8.6.2024 7.42.00	8.6.2024 4.23.33	NOT FOUND
10	AY19	HEL - DFW	7.6.2024 10.05.00	7.6.2024 19.35.00	7.6.2024 17.46.01	7.6.2024 19.40.05
11	AY132	SIN - HEL	6.6.2024 14.14.00	7.6.2024 2.51.00	7.6.2024 2.13.10	NOT FOUND
12	AY131	HEL - SIN	5.6.2024 21.41.00	6.6.2024 10.22.00	6.6.2024 8.23.00	NOT FOUND
13	AY122	DEL - HEL	5.6.2024 2.30.00	5.6.2024 10.58.00	5.6.2024 10.10.50	5.6.2024 11.03.10
14	AY121	HEL - DEL	4.6.2024 15.42.00	4.6.2024 23.03.00	4.6.2024 22.05.58	4.6.2024 23.21.33
15	AY132	SIN - HEL	3.6.2024 13.54.00	4.6.2024 2.44.00	4.6.2024 2.10.42	NOT FOUND
16	AY131	HEL - SIN	2.6.2024 22.10.00	3.6.2024 10.35.00	3.6.2024 8.38.35	NOT FOUND
17	AY1338	LHR - HEL	2.6.2024 18.01.00	2.6.2024 20.22.00	NOT FOUND	2.6.2024 20.27.21
18	AY1337	HEL - LHR	2.6.2024 13.45.00	2.6.2024 16.08.00	NOT FOUND	NOT FOUND
19	AY122	DEL - HEL	2.6.2024 2.27.00	2.6.2024 10.55.00	2.6.2024 7.58.04	NOT FOUND
20	AY121	HEL - DEL	1.6.2024 15.44.00	1.6.2024 23.02.00	1.6.2024 22.20.12	1.6.2024 23.13.54
21	AY2	LAX - HEL	1.6.2024 3.05.00	1.6.2024 13.11.00	1.6.2024 10.00.24	NOT FOUND
22	AY1	HEL - LAX	31.5.2024 14.22.00	1.6.2024 0.39.00	31.5.2024 20.52.59	NOT FOUND
23	AY122	DEL - HEL	31.5.2024 2.45.00	31.5.2024 11.12.00	31.5.2024 9.29.56	NOT FOUND
24	AY121	HEL - DEL	30.5.2024 15.39.00	30.5.2024 22.51.00	30.5.2024 22.01.40	NOT FOUND
25	AY1332	LHR - HEL	30.5.2024 10.04.00	30.5.2024 12.26.00	30.5.2024 11.48.27	30.5.2024 12.31.08
26	AY1331	HEL - LHR	30.5.2024 5.15.00	30.5.2024 7.42.00	NOT FOUND	NOT FOUND
27	AY132	SIN - HEL	29.5.2024 14.16.00	30.5.2024 2.56.00	30.5.2024 1.08.53	NOT FOUND
28	AY131	HEL - SIN	28.5.2024 21.44.00	29.5.2024 10.01.00	29.5.2024 8.17.05	NOT FOUND
29	AY100	HKG - HEL	27.5.2024 12.58.00	28.5.2024 1.54.00	28.5.2024 0.25.16	NOT FOUND
30	AY99	HEL - HKG	26.5.2024 21.56.00	27.5.2024 9.22.00	27.5.2024 8.12.04	NOT FOUND
				Total:	26	10
				Result:	PASS	

Minimum 15 matching reports are required from either report type for signing NMSB as completed for the specific engine.

Checked by (Name and Date):

Setup | Single Engine Report | Fleet Overview Report

Figure 6. Single Engine Report

Fleet Overview Report

The Fleet Overview Report gives a view of the same end results for the whole fleet as the Single Engine Report would give for the one engine (Figure 7). It does not however display data that the results are based on. When the Fleet Overview Report is used as proof of completion for the NMSB, it is also good to include the data that the results are based on together with the report. With this practice, the results of the report can be verified from the data afterwards if required. When performing the NMSB this way only for a single engine, this requirement for additional archived files complicates the process compared to the Single Engine Report where all the required data is on one PDF file. On the other hand, when performing the NMSB for the whole fleet, all the engines can use the exact same PDF report and data as long as their results are successfully loaded into the report.

Trent XWB-72-AL055 Fleet Data Quantity Overview Report

This Report is to be used when performing Rolls Royce NMSB Trent XWB-72-AL055 according to compliance method B.

Checked by (Name and Date): Esimerkki Erkki 12.6.2024

Latest Aircraft UtilizationData Record: 12.6.2024 10.38.00

7	Engine Serial Number	Registration	Engine Position	Cruise Reports	Flight Summary Reports	Result
8	[redacted]	OH-LWE	1	23	30	PASS
9	[redacted]	OH-LWE	2	23	30	PASS
10	[redacted]	OH-LWL	1	23	30	PASS
11	[redacted]	OH-LWL	2	23	30	PASS
12	[redacted]	OH-LWK	1	24	27	PASS
13	[redacted]	OH-LWK	2	24	26	PASS
14	[redacted]	OH-LWF	1	25	29	PASS
15	[redacted]	OH-LWF	2	25	28	PASS
16	[redacted]	OH-LWO	1	25	29	PASS
17	[redacted]	OH-LWO	2	25	30	PASS
18	[redacted]	OH-LWP	1	25	30	PASS
19	[redacted]	OH-LWP	2	25	30	PASS
20	[redacted]	OH-LWC	1	26	29	PASS
21	[redacted]	OH-LWC	2	26	29	PASS
22	[redacted]	OH-LWG	1	26	11	PASS
23	[redacted]	OH-LWG	2	26	28	PASS
24	[redacted]	OH-LWI	1	26	30	PASS
25	[redacted]	OH-LWI	2	26	30	PASS
26	[redacted]	OH-LWM	1	26	28	PASS
27	[redacted]	OH-LWM	2	26	30	PASS
28	[redacted]	OH-LWN	1	26	30	PASS
29	[redacted]	OH-LWN	2	26	29	PASS
30	[redacted]	OH-LWR	1	26	29	PASS
31	[redacted]	OH-LWR	2	26	29	PASS
32	[redacted]	OH-LWA	1	27	29	PASS
33	[redacted]	OH-LWA	2	27	27	PASS
34	[redacted]	OH-LWH	1	27	28	PASS
35	[redacted]	OH-LWH	2	27	30	PASS
36	[redacted]	OH-LWS	1	27	29	PASS
37	[redacted]	OH-LWS	2	27	30	PASS
38	[redacted]	OH-LWB	1	29	28	PASS
39	[redacted]	OH-LWB	2	29	26	PASS
40	[redacted]	OH-LWD	1	29	30	PASS
41	[redacted]	OH-LWD	2	29	30	PASS

Setup | Single Engine Report | Fleet Overview Report

Figure 7. Fleet Overview Report

Development Process

During the development of the tool, problems occurred with unacceptably long times that the report needed to load the data and construct it into a report. Up to two hours of data refresh time was measured with all files selected on the setup page. This was found to be caused by a lack of data buffering. Every time the query data is referenced Power query loads the data from the file and performs all steps to it until the point it is referenced, if there is no buffering happening somewhere along the steps where buffered data can be loaded with all the previous steps already performed. The problem especially escalated when a query was needed as a reference for the creation or transformation of nested tables. In those cases, data was loaded all the way from the file and steps performed to it as many times are there were rows in the table. By using Table.Buffer() function at the end of the steps of source queries or any data that is referenced multiple times, Excel refresh time was reduced from two hours to under three minutes. Effects can also be seen from the Excel Queries & Connections -view, where originally from 500 kb file near 500 mb was loaded and after buffering this was reduced back to 500 kb. This means that without buffering original file was loaded a thousand times and it resulted in unacceptably long load times.

3.1.2 Required Data

For the method B completion user must have access to the Rolls Royce EHM site, where the engine health monitoring data is collected. The site has its own pages for downloading Flight Summary-Short Reports and Cruise Reports. EMU Flight Summary-Short Reports, which are also called in some instances End of Flight Reports, are generated after the plane has landed. Recorded report times were found to be within 15 minutes after the arrival time. Cruise reports are generated during the flight at unknown intervals. The longer the flight the more Cruise Reports are sent. It was found that on shorter flights like from Helsinki to London not a single report might be received by Rolls Royce. On the other hand, on long flights, even three reports can be received. This becomes an important factor to take into consideration if a plane is flying mostly shorter routes when there might not be enough Cruise Reports to perform the MNSB.

At the EHM site user must select the dates from which the data is downloaded and the format of the table data. Tables do not include any information about the reports other than when it is generated and from which engine and aircraft it is from. Contents of the reports are processed by Rolls Royce and are not directly accessible by the operator. The downloaded tables are only for confirming from which flights the reports are received by Rolls Royce. All the data downloaded from the EHM site must be in CSV format, the separator symbol must be a semicolon, and the date format must have first days then months and then a year. Symbols separating the date information were found not to be important since Power Query was found to be able to recognize it regardless of the symbols as long as the order was correct. These regional settings can be found in the Rolls Royce EHM portal's personal settings.

Aircraft utilization data, which includes information when planes have flown is accessible in Finnair's AMOS system. Data is collected from the aircraft's electronic flight log to which the pilot inputs information about the flight, which includes required information for the data quantity verification like departure airport, arrival airport and take-off and landing times. AMOS is able to output data in any format according to the user's needs. Correct download format and regional settings are shown in the Method B Guide (Appendix 1).

As there is plenty of data required for the NMSB to be completed according to the method B, a flowchart was created to show the data flow from the aircraft, all the way to the engineer (Figure 8). It also shows the data movement after the engineer has performed the initial analysis, which exists for archiving purposes. All the data handled by the engineer is displayed in red in the flowchart.

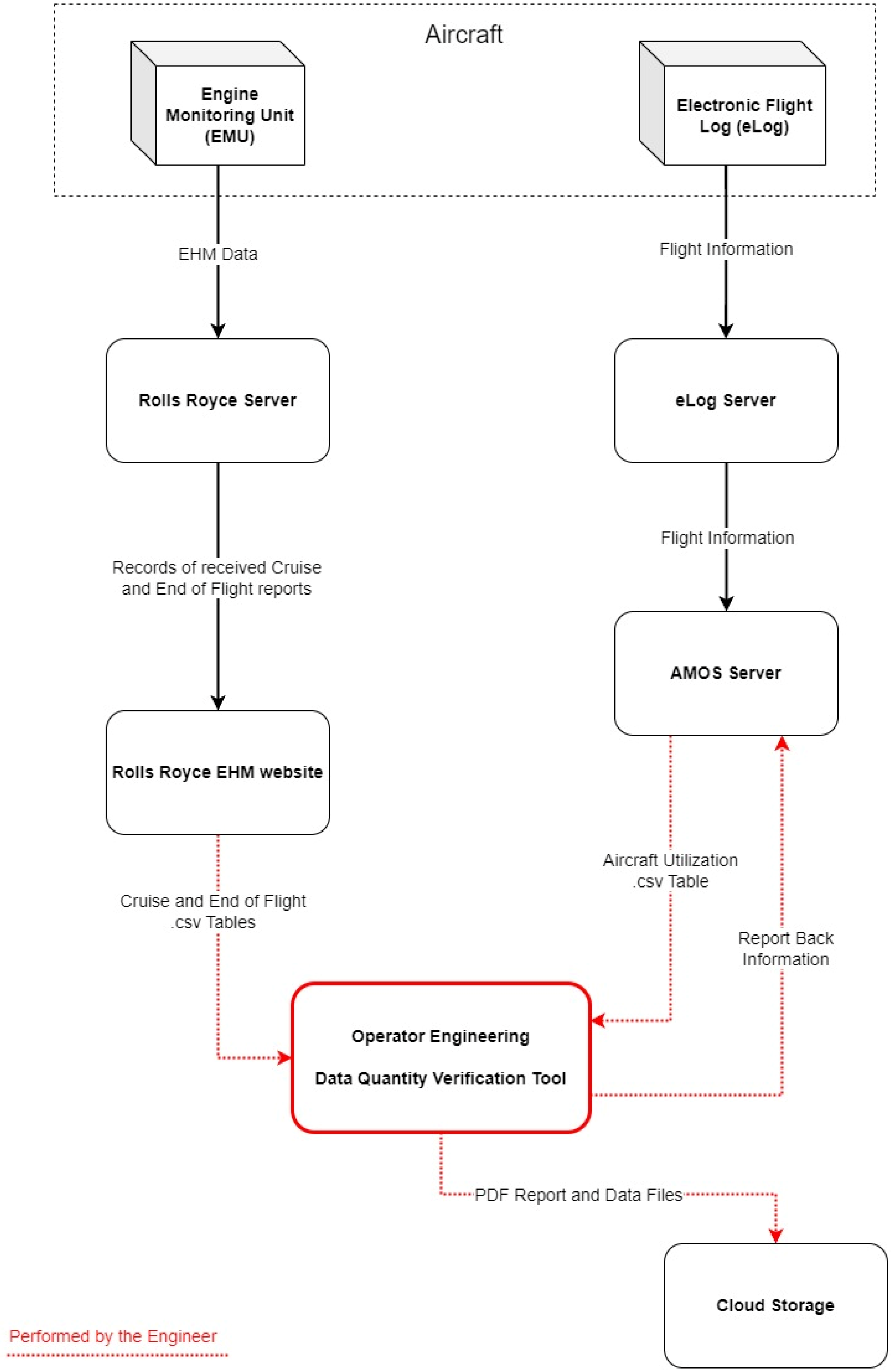

Figure 8. Method B Information Flow

3.1.3 Engine alerts

In the Trent XWB engine, EEC and EMU monitor their assigned sensors and share the information between them and to the aircraft systems and pilots through digital data busses and discrete analogue interfaces (Rolls Royce plc 2023). In the case of vibration alerts Intermediate Case Vibration Transducer value is read by EMU which then sends the value through the AFDX network to the CDS and creates an alert if values are exceeding limits. Alerts are also sent to the Rolls Royce EHM site, where engineers can view the alerts remotely (Figure 8). This is necessary when performing the NMSB to fulfil the requirement of having no open vibration or ARP alerts.

3.1.4 Results

After performing the data quantity verification multiple times during the testing of the tool, it was found that it is unlikely that there would not be enough Cruise or Flight Summary-Short Reports at the same time to fulfil the required amounts if engines have flown at least 30 flights after the installation. Not a single engine like this was found. However, enough Flight Summary-Short Reports were missing in some of the cases. This occurred mostly with the same engines, which might be caused by transmission problems on the specific engine or aircraft. The amount of Cruise Reports was always satisfactory but some amounts that were barely above the limit were found. This indicates that it is not guaranteed to always have a satisfactory amount of Cruise Reports either. By far the most common reason for the failure of the data quantity verification was the missing reports due to the time of engine being off-wing. This can be however overcome by performing the verification subsequently at the date of engine removal.

3.2 Borescope Inspection

3.2.1 Introduction to the Borescope Inspection

Borescope inspection is a common method in aircraft maintenance when visual inspection of areas with limited access is required. Borescopes which are also referred to as fiberscopes or videoscopes are tools with flexible or rigid tubes which transmit an image from the end of the tube to the display. View at the tube tip can be often articulated with controls at the display. Borescope inspection is a useful and common inspection method, especially in aircraft engine maintenance applications, when there is limited access to the engine's inner parts without disassembling the engine. Disassembly of the engine modules is only possible in specialized engine shops due to the size, complexity and criticality for flight safety. Borescope inspections allow operators to inspect components inside the engine for wear, damage and foreign objects, which in some cases are done in regular intervals and in some cases after abnormal incidents like over-limit engine operations or bird strikes.

3.2.2 Guidance From the Rolls Royce

NMSB gives thorough step-by-step guidance for the inspection. It references Airbus AMM for the removal and installation of Rear Intermediate Pressure Turbine Overheat Temperature Thermocouple. Rolls Royce also provides visual video guidance of the borescope inspection on their Yocova training platform, which visualizes how the borescope must be moved inside the engine. Regardless of the compliance method, the NMSB instructs to record accomplishments in accordance with local SB tracking system procedures (Rolls Royce plc 2024a). At Finnair, this is done in the AMOS system.

3.2.3 Tooling

Borescope

NMSB instructs to use a 4mm borescope with image or video capture capability, without specifically stating the model or manufacturer (Rolls Royce plc 2024a). In the Rolls Royce Power Point presentation about the NMSB it is also mentioned that the borescope should be at least 3 m long (Roll Royce plc 2024b). The borescope used for the trial was an Olympus IV9000N with a 4 mm thick and 3,5 m long insertion tube and AT120D/NF-IV94N optical adaptor, which Finnair already had in the tool store (Figure 9). IV9000N base unit includes functions for distance and surface area measurements. It is also possible to create colour 3D models of the examined objects, which can be rotated around in the display. These features are however not necessary for inspection, since only the presence of the anti-rotation plates must be confirmed. A wide view of the optical adaptor was found to be beneficial during the trial since it helps to get a view of anti-rotation plates after the last bend. Therefore at least a 120-degree view angle will be recommended.

Figure 9. Olympus Borescope (Evident)

Turning Tool

For rotating the HP system 360 degrees to see all anti-rotation plates, a turning tool was needed. Rolls Royce advises to use a turning tool RRT106315 and has a procedure for its use in the engine manual (Rolls Royce plc 2024a). The turning tool is inserted into a breather hole on the accessory gearbox, which allows it to connect with splines on the gearbox. The turning tool has a clutch to protect the engine from overtorque. However, the manual also calls for a torque wrench to be used when turning it (Rolls Royce plc 2024c).

Thermocouple Protector

Rolls Royce offers protector RRT116239 to be used on thermocouple wires (Rolls Royce plc 2024a). It keeps wires from bending in the first 10 mm from the thermocouple and ensures that the bending radius is at least 13mm, where electrical leads connect to the thermocouple body (Rolls Royce plc 2019). This spot in the thermocouple is fragile since the metal outer shell of the electrical leads is vulnerable to sharp bending.

Immobilizer

Immobilizer HU44525-2 or RRT061241 is used to prevent movement of the LP compressor spool (Rolls Royce plc 2024a). It is installed between the fan tips and the fan casing, which creates enough friction to prevent the spool from rotating. NMSB also gives the option to use alternative tools if they fulfil the requirements of the appropriate regulatory airworthiness authority (Rolls Royce plc 2024a). Due to the simplicity of the tool, which is constructed from two rubber wedges connected with rope, it is possible to self-manufacture such a tool.

3.2.4 Trial of BSI

A trial of borescope inspection was performed on an engine, that was already removed from the aircraft to be sent for a shop visit (Figure 10). This made sure that if damage would be caused to an engine during the trial it would not affect flight operations. The engine was already covered with the transportation cover, which was opened just enough to get access to the required location. A work stand made for widebody engine maintenance was placed on the right side of the engine for safe access to the borescope insertion location. Access was also required for the turning tool installation location and the bottom of the fan case, where the installation hole is located at the auxiliary gearbox.

Figure 10. Trial Engine

BSI was started by removing a rear IP turbine overheat temperature thermocouple. Work instructions called to use protector RRT116239 on the thermocouple (Rolls Royce plc 2024c). The purpose of it is to protect the leads to the thermocouple connection joint from getting bent during removal and installation. Protector was not available for use at the time of the BSI trial, so the procedure was attempted without it. At first, the engineer removed the thermocouple attaching screws and started removing the clamps holding the thermocouple leads one by one to see how much disassembly was required for getting the thermocouple out of its hole since complete removal was not necessary for BSI inspection (Figure 11). During this procedure, one lead broke off from the thermocouple and made the thermocouple unserviceable. Before beginning the disassembly, it was noticed that the broken-off lead had white insulation visible from the connection join which may indicate it being weakened before the trial started. The conclusion was made from this that it is best to remove the thermocouple and its leads completely from the engine and to use the protector stated in the manual to avoid bending the leads.

Figure 11. Borescope Insertion Location

After the thermocouple was removed, the engineer started feeding the borescope insertion tube into the thermocouple hole. The path for the tube was described in the NMSB. At the beginning of the path, the tube must go around an obstacle since it is thicker than the thermocouple and cannot fit all the way along the same path (Rolls Royce plc 2024a). When the tube has been fed to travel along the axle, increased friction makes tube feeding more difficult. It took multiple tries to get the tube fed far enough along the axle. Slight rotation and pulsating forward movement helped to overcome friction and allow the tube to be fed further. When the correct breather hole was reached, just by using the joystick to turn the view around the corner, a view of the anti-rotation plates was reached (Figure 12). Finally, the HP axle was rotated 360 degrees with a rotation device to get a view of all the anti-rotation plates.

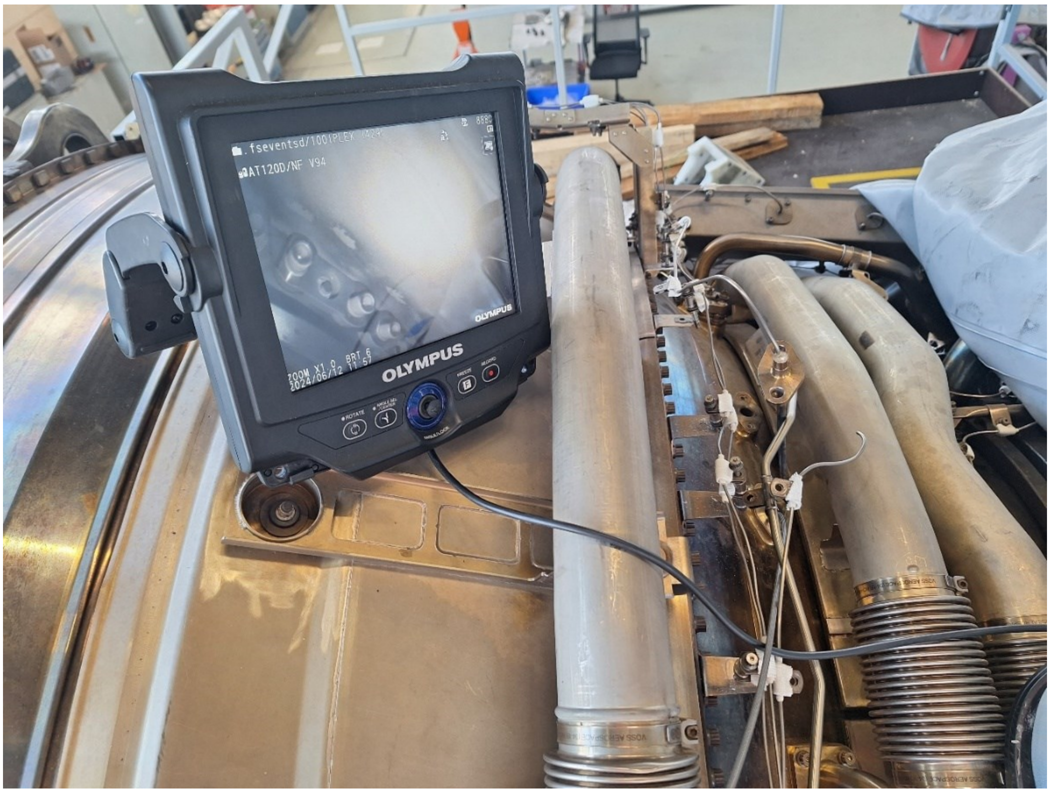

Figure 12. Reached view of the Anti-Rotation Plates

After the presence of the anti-rotation plates was confirmed, the borescope tube was slowly removed from the engine while making sure that it did not get stuck. If inspection is to be done for an operative engine, the thermocouple and its leads would be installed back according to AMM. In this case, since the engine was going for a shop visit and the thermocouple was to be replaced anyway, only necessary actions for shipment were taken.

4 Recording Actions

Since NMSB must be completed every 700 EFC, a reliable way of tracking the flight cycles of the engines was required. Finnair uses AMOS system developed by the Swiss-AS that is used for controlling all the information around the maintenance activities. AMOS is also linked to the aircraft's electronic logbooks from where it gets information about flights of the aircraft. A maintenance event was set up in the AMOS which tracks the cycles of the engine even when it is transferred to another airframe, since AMOS has also information about to which airframe engine serial number is installed. The maintenance event was set to 600 EFC to give room to perform the verification again if there was not enough data on the first try.

When the compliance method B is used, the NMSB instructs to record evidence of EHM criteria with a form that the NMSB gives as a suggestion (Rolls Royce plc 2024a). However, the report generated by the data quantity verification tool fulfils its purpose. A cloud storage folder was set up for the archival of the generated reports and data files so that the correct accomplishment of the NMSB can be verified afterwards.

When the flight cycle count comes soon to be due, the engineer performs the data quantity verification and stores the created report and associated data files in the cloud storage folder for archival. Then the engineer reports back the maintenance event to AMOS, which resets the flight cycle counter and records the completion into the aircraft's maintenance logs. In case of a failure of the data quantity verification and when it is not possible to redo the verification later, the engineer must create a workorder for the borescope inspection. When the borescope inspection has been successfully performed, the engineer can with the results of the borescope inspection report back the maintenance event.

5 Summary

The task was given to investigate, perform and improve both of the on-wing methods stated in the NMSB. It was found that there are its own challenges in performing the NMSB by either of the methods. Due to the risk of extra costs and labour intensity of the method A borescope inspection, it is always best to first attempt the completion according to the method B data quantity verification if there are no vibration or ARP alerts active on the engine. This is especially beneficial since the verification can be performed for the whole fleet simultaneously with almost the same amount of work time required. If any of the ARPs are found to be detached, the engine must be sent to a repair facility with no fly-on allowed.

During the BSI overtemperature probe was found to be easily damaged if the leads were not completely detached from the clamps and the protector used. It would lead to additional expenses and if there are no spare parts available, to a possible delay or cancellation of flights. In addition, reaching the ARP location with the borescope is not guaranteed. The location is difficult to reach due to the increased friction of the insertion tube after a long insertion distance and many bends. It is recommended that this BSI is only assigned to more experienced inspectors.

For the data quantity verification, a tool was created by using Power Query and Excel. Usage of the tool requires a subscription to the Rolls Royce EHM services and access to the EHM site. Report files are downloaded from the EHM sites and compared by the tool to the aircraft utilization files from the AMOS. If enough reports from the EMH site are matching to the aircraft utilization from the last 30 flights and the are no open vibration or ARP alerts, NMSB can be signed as completed to the AMOS after archiving results to the cloud storage. If completion is not possible with the data quantity verification, a BSI must be performed. Data quantity verification is primarily meant to be performed by engineers who have a good understanding and skills from handling data on a computer.

NMSB was found to be overall not so straightforward to perform and requires large amounts of research and preparations. With some previous experience, an engineer can however complete the NMSB only in a couple of hours for the whole fleet by using this thesis together with the Method B Guide and the data tool as an aid when all the required conditions are met. This points out the importance of researching and planning for this and other future service bulletins since the sudden mandatory completion can disturb flight operations drastically and cause a loss of revenue. Especially when service bulletins are often concerning the whole fleet of the specific aircraft type.

Possible future research would be to investigate the reasons why so many Cruise or End of the Flight -reports are not received by the Rolls Royce and why it is happening more on some airframes than others. It would be useful information, which could help to detect possible system faults sooner if those transmission problems can be fixed. It would also improve the reliability of successfully performing this NMSB. Regarding the NMSB, there are no significant areas for additional research unless the NMSB would be updated and new requirements would arise.

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72-AL055 Compliance Method B Guide

Recording Evidence of Meeting EHM Criteria

Finnair Technical Services
Powerplant Management
Revision 0, original revision
26.11.2024

Contents

1 Introduction

1.1 Effectivity

This guide is meant to be used when performing the NMSB TrentXWB-72-AL055 according to compliance method B for the Finnair Airbus A350 fleet with Trent XWB-84 engines. This guide or the report tool does not take into account any variables, that will occur when using them for any other operators, equipment or purposes. The user must confirm that the results of the analysis comply with the latest revision of the NMSB TrentXWB-72-AL055.

1.2 Report tool

The report tool is running on Excel, but the data processing is happening in Power Query, which it feeds to the Excel -table according to the user input. It is possible to get two kinds of reports from the tool. Single Engine Report is to be used when there is a need for a detailed view of the last 30 flights of the aircraft and to know from which specific flights there are Cruise Reports or Flight Summary-Short Reports found. This can be used to find possible problems in report generation or for trying to find missing reports that the tool did not find. Fleet overview report is to be used when you need an overview of reports found for all engines. It does not however provide details from what the results are based on. Both reports can be used to sign the NMSB as completed. However, you need to include the data files used in the generation of the Fleet Overview Report with the report itself, since the flight data is not displayed in the report.

2 Downloading Reports

2.1 Aircraft Utilization

a. Open Aircraft Utilization (APN:206) at AMOS.

b. From the Search menu, select A/C type: **Airbus A350**

c. From the Select Data menu, **select all the aircraft for which the analysis is made**.

d. For Time Selection, to a To-date select **the current date** and to a From-date select **a date about two months back**.

Note: In some cases when an aircraft has been operated less than a normal amount, a date further back must be selected to get the last 30 flight cycles.

e. From Time Selection, click **Search**. Utilization data comes into view.

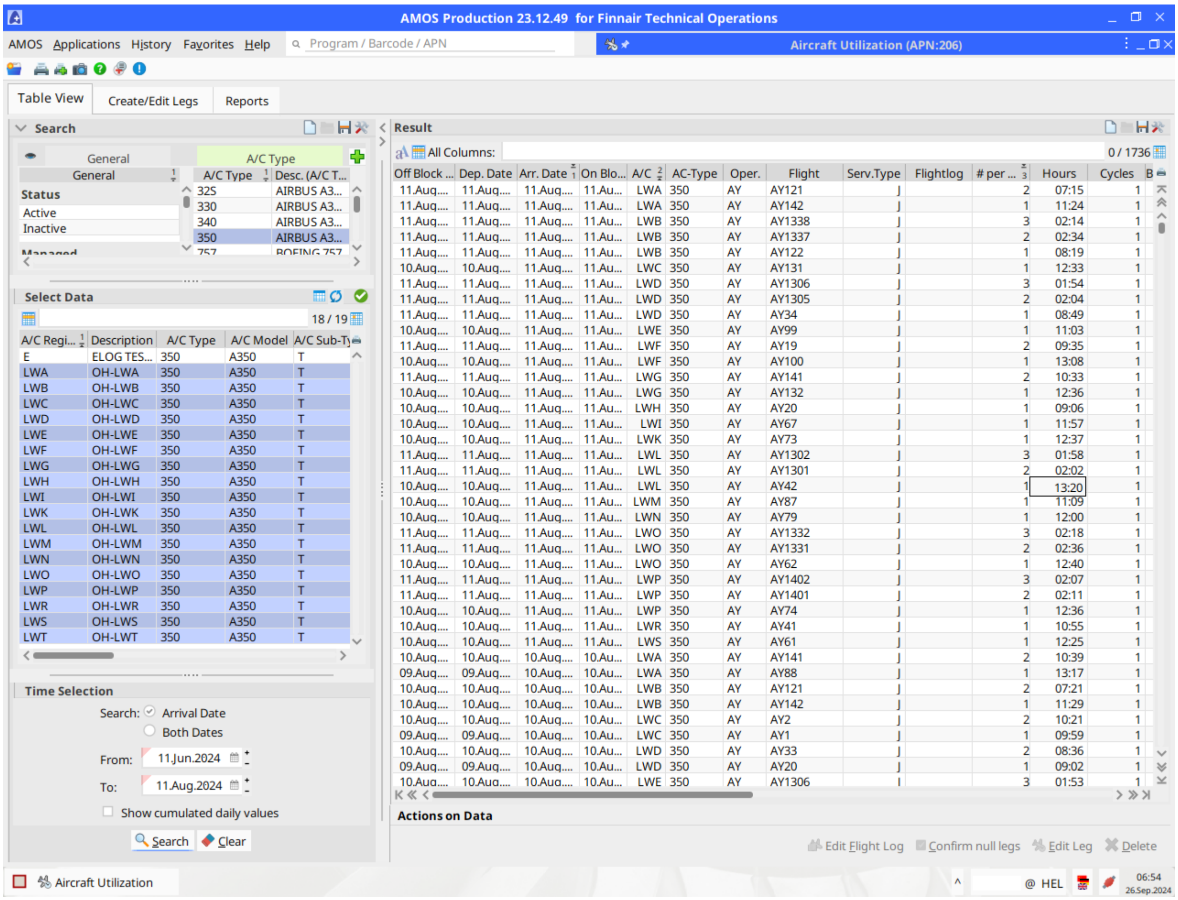

Figure 1, Aircraft Utilization (APN:206)

f. Click the small **printer icon** at the top right corner of the Results view. Report Generator comes into view.

g. For Choose a report Select:

Report: Aircraft Utilization
Data Types: CSV File
Destination: Save to disk

h. For Destination Detail, select the preferred file location and name by double-clicking the text field.

i. For parameters select **Include Headers** and uncheck everything else (Excluding Column settings).

j. Select These format settings:

Delimiter: Comma
Date Format: dd.MMM.yyyy
Country: US

k. Select the following columns:

Dep. Date
Arr. Date
A/C
Flight
Dep.
Arr.
Dep.Time
Arr.Time

l. Click **OK**. A report will be generated to the selected location.

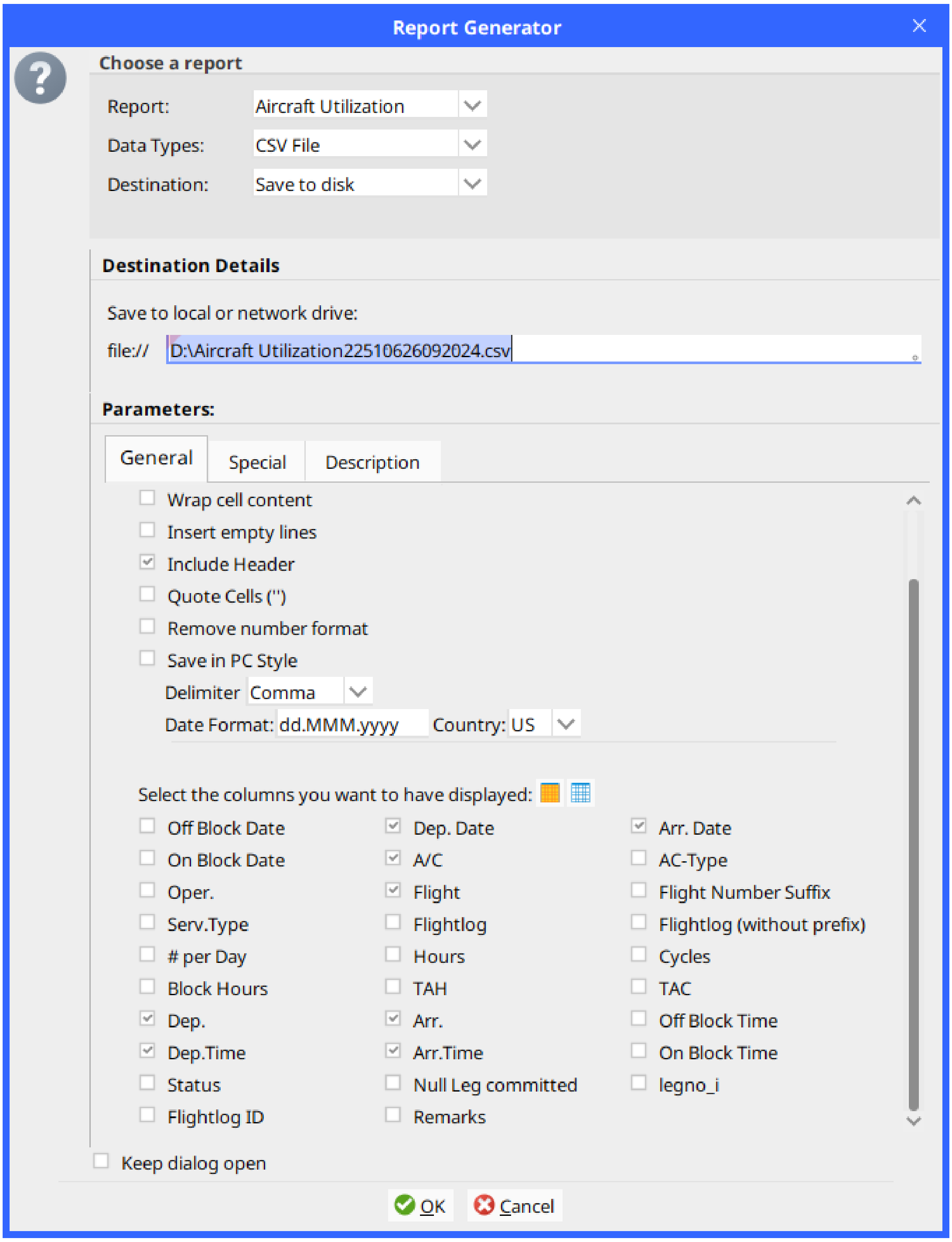

Figure 2, Aircraft Utilization, Report Settings

2.2 Accessing Rolls Royce Care Exports

a. Go to the Rolls Royce Care website and log on with your credentials: https://secure.portal.rolls-royce.com/RRLogon/LogonExternal.jsp

Note: If you don't have credentials for Rolls Royce Care, you can fill out the user registration form on the Finnair Company Hub A350 engine page.

b. From the **Services** tab click **Engine Health Monitoring** and from the new view select **Finnair** under the Account Description. EHM Home page comes into view.

c. From the top menu select **System** → **Administration**.

d. Move the cursor over the **Menu**-text on the left and from the new menu that comes into view select **Personal Details**.

e. As **xls, csv and doc export locale** select **Finnish (Finland)**.

f. From the top left corner click the **home icon**.

g. Select the engine **Trent XWB-84** from the EHM Home Page

h. Move the cursor over the **Engine Health Monitoring** -text in the upper left corner and from the menu that comes into view select **Data Export** → **Predefined Exports**.

i. For downloading Cruise Reports or both reports, continue to Chapter 2.3 and for downloading only Flight Summary-Short Reports go to Chapter 2.4.

2.3 Cruise Reports

a. Move the cursor over the **Menu** text on the left and from the new menu that comes into view select **NMSB 72-AL055** → **Cruise Data**. The data export page comes into view.

b. Insert the following criteria into the filters:

Operator:	Finnair
Choose:	Equipment List
Select:	FIN-fleet
View:	All
From:	(Date about two months back)
To:	(Current date)
Export to:	csv

Note: If you are performing data quantity analysis for a specific engine, you can alternatively select the serial number of that engine in **View**-filter to reduce file size.

Note: In some cases when an aircraft has been operated less than a normal amount, a date further back must be selected to get the last 30 flight cycles.

c. Click **Export** and wait for the file to download.

d. For downloading also Flight Summary-Short Reports, continue to chapter 2.4, otherwise go to chapter 3.1.

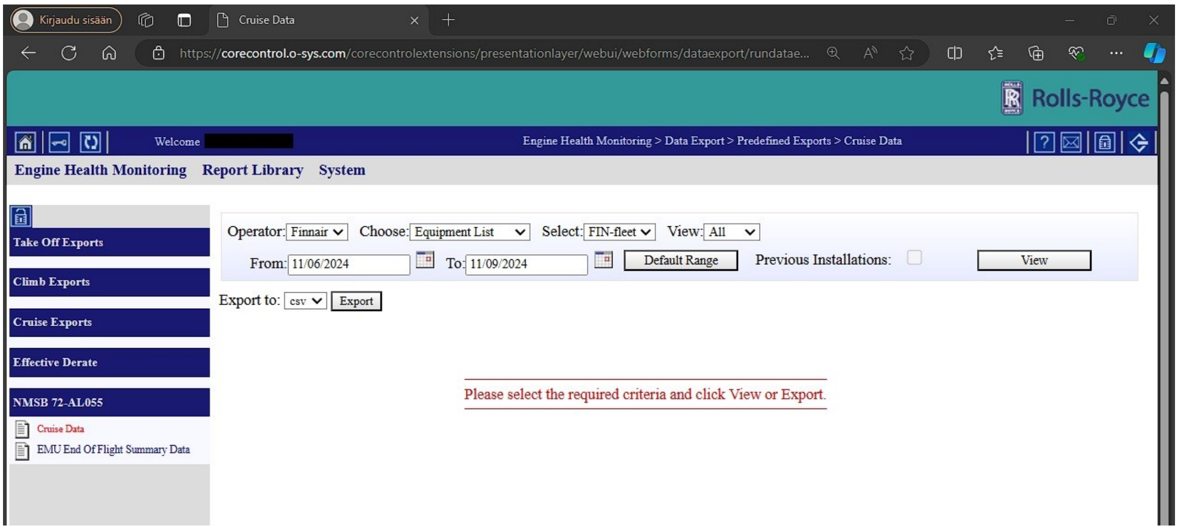

Figure 3. RR Engine Health Monitoring Site, Cruise Data Download Page

2.4 Flight Summary-Short Reports

a. Move cursor over the **Menu**-text on the left and from the new menu that comes into view select **NMSB 72-AL055** → **EMU End of Flight Summary Data**. The data export page comes into view.

b. Insert the following criteria into the filters:

Operator:	Finnair
Choose:	Equipment List
Select:	FIN-fleet
View:	All
From:	(Date about two months back)
To:	(Current date)
Export to:	csv

Note: In some cases when an aircraft has been operated less than a normal amount, a date further back must be selected to get the last 30 flight cycles.

c. Click **Export** and wait for the file to download.

3 Data Quantity Analysis

3.1 Report Generator Setup

a. Download the report tool from the location specified in the AMOS maintenance event.

Caution: Use always blank report tool that does not have previous reports saved to avoid data mix-up.

b. Open the report generator.

c. Click to open the **Setup** sheet from the down left corner.

d. If you see Data Warning: “External Data Connections have been Disabled”, click **Enable Content**.

e. To the Setup page you need to fill in the complete file paths of each report file. You can do this in Windows 10 by holding SHIFT, right-clicking the file and selecting **Copy as path**.

f. If you wish to generate a Fleet Overview Report go to Chapter 3.2.1 and for Single Engine Report, go to Chapter 3.2.2.

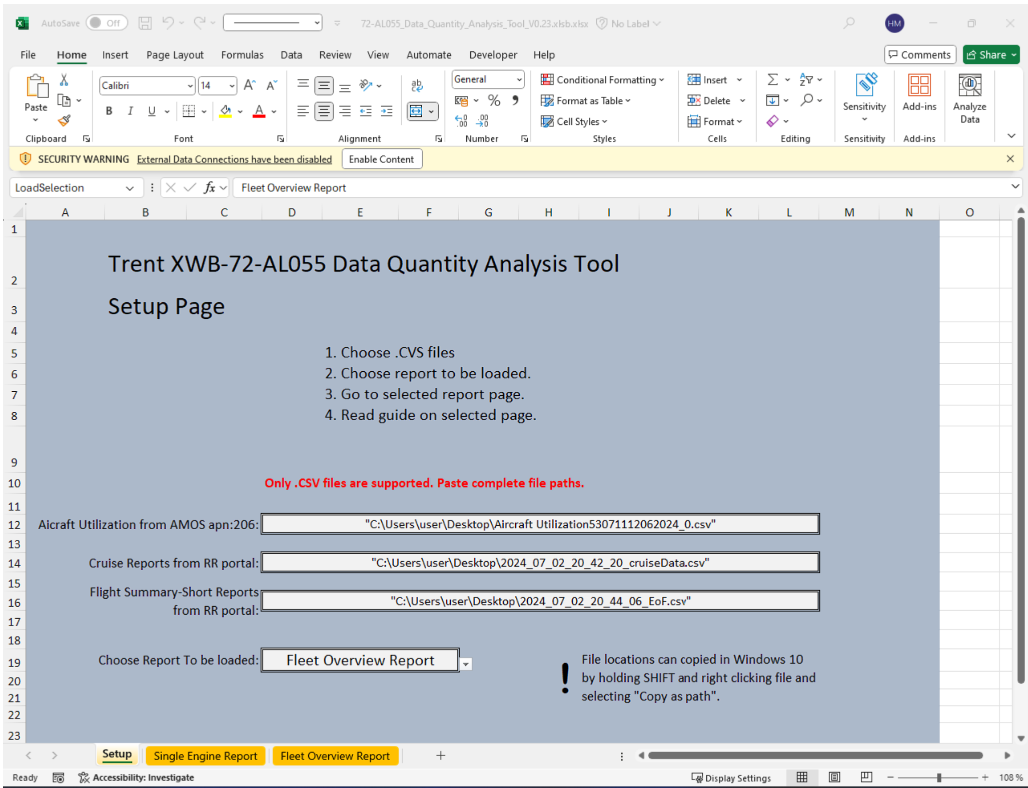

Figure 4. Report tool, Setup page

3.2 Generating a Report

3.2.1 Fleet Overview Report

a. On the Setup page select **Fleet Overview Report** as report to be loaded from the drop-down menu.

b. From the bottom sheet selection, select **Fleet Overview Report**. The overview report sheet opens.

c. Under the **Data tab** click **Refresh All**. The report begins to generate.

d. Under the **Data tab** click **Queries & Connections**. View of loading queries open.

e. Wait until all queries stop loading and make sure that none of them have “Download did not complete” -warning under them. Scroll down to see all queries.

f. Make sure that the Latest Aircraft Utilization Data Record has the current date or the date when any of the aircraft has flown for the last time. If not, you need to change the aircraft utilization data to a newer one.

g. You can now see the results on the report. On the right side of the table, there is a Pass or Fail result for each engine. On Cruise Reports and Flight Summary-Short Reports -columns you can see the number of reports found. An insufficient number of reports are highlighted with yellow when the number is 14 or lower. The result might still be a Pass since only one type of report must have a 15 or higher number of matches. If both types are 14 or under, the result is a Fail.

h. View the data and make sure that the table is filled correctly:

- **Table displays all necessary engines.**
- **Latest Aircraft Utilization Data Record displays the latest time when any of the aircraft has landed. This is to make sure that utilization data is not too old.**
- **Results match the displayed data.**
- **Table results fulfil the requirements of the latest revision of Rolls Royce NMSB TrentXWB-72-AL055.**

i. After you have made sure that the data is correct write your name or AY-number to the Checked By -field.

j. Go to Chapter 3.3 to save your report.

5. Refresh report by selecting "Refresh All" from "Data" -tab.

6. Make sure that all queries have been successfully loaded by opening "Data" -> "Queries & connections" before using any results.

Trent XWB-72-AL055 Fleet Data Quantity Overview Report

This Report is to be used when performing Rolls Royce NMSB Trent XWB-72-AL055 according to compliance method B.

Checked by (Name and Date): Esimerkki Erkki 12.6.2024

Latest Aircraft UtilizationData Record: 12.6.2024 10.38.00

Engine Serial Number	Registration	Engine Position	Cruise Reports	Flight Summary Reports	Result
[redacted]	OH-LWE	1	23	30	PASS
[redacted]	OH-LWE	2	23	30	PASS
[redacted]	OH-LWL	1	23	30	PASS
[redacted]	OH-LWL	2	23	30	PASS
[redacted]	OH-LWK	1	24	27	PASS
[redacted]	OH-LWK	2	24	26	PASS
[redacted]	OH-LWF	1	25	29	PASS
[redacted]	OH-LWF	2	25	28	PASS
[redacted]	OH-LWO	1	25	29	PASS
[redacted]	OH-LWO	2	25	30	PASS
[redacted]	OH-LWP	1	25	30	PASS
[redacted]	OH-LWP	2	25	30	PASS
[redacted]	OH-LWC	1	26	29	PASS
[redacted]	OH-LWC	2	26	29	PASS
[redacted]	OH-LWG	1	26	11	PASS
[redacted]	OH-LWG	2	26	28	PASS
[redacted]	OH-LWI	1	26	30	PASS
[redacted]	OH-LWI	2	26	30	PASS
[redacted]	OH-LWM	1	26	28	PASS
[redacted]	OH-LWM	2	26	30	PASS
[redacted]	OH-LWN	1	26	30	PASS
[redacted]	OH-LWN	2	26	29	PASS
[redacted]	OH-LWR	1	26	29	PASS
[redacted]	OH-LWR	2	26	29	PASS
[redacted]	OH-LWA	1	27	29	PASS
[redacted]	OH-LWA	2	27	27	PASS
[redacted]	OH-LWH	1	27	28	PASS
[redacted]	OH-LWH	2	27	30	PASS
[redacted]	OH-LWS	1	27	29	PASS
[redacted]	OH-LWS	2	27	30	PASS
[redacted]	OH-LWB	1	29	28	PASS
[redacted]	OH-LWB	2	29	26	PASS
[redacted]	OH-LWD	1	29	30	PASS
[redacted]	OH-LWD	2	29	30	PASS

Setup | Single Engine Report | Fleet Overview Report | +

Figure 5. Fleet Overview Report, Engine serial numbers censored.

3.2.2 Single Engine Report

a. On the Setup page select **Single Engine Report** as report to be loaded.

b. From the bottom sheet selection, select **Single Engine Report**. The report sheet opens.

c. Under the **Data** tab click **Refresh All**.

d. Under the **Data** tab click **Queries & Connections**. View of loading queries open.

e. Wait until all queries stop loading and make sure that none of them have "Download did not complete" -warning under them. Scroll down to see all queries.

f. From engine selection, select the engine to which you are performing the analysis.

g. Select the date of the last flight for the engine. If the engine is on-wing and has flown at least 30 flights, you must write the date of today. If the engine is removed or not yet flown 30 flights after the installation, the date of last removal is to be used. In this case, you must also select pre-removal registration and position for the engine.

h. Under the **Data** tab click **Refresh All**. The report begins to generate.

i. Wait until all queries stop loading and make sure that none of them have "Download did not complete" -warning under them. Scroll down to see all queries.

j. You can now see the results on the report. At the bottom of the report, there is a Pass or Fail result for the engine. On the Cruise Report and Flight Summary-Short Reports -columns you can see from which flights the reports are found and the number of found reports at the end. Missing reports are highlighted with yellow and an insufficient number of reports are highlighted with red when the number is 14 or lower. The result is a Pass when at least one type of report has a 15 or higher number of matches. If both types are 14 or under, the result is a Fail.

k. View the data and make sure that the table is filled correctly:

- **Selected aircraft is correct.**
- **Flights start counting backwards from the correct date.**
- **Flights match the flights flown by the selected aircraft**
- **Results match the data displayed above.**
- **Table results fulfil the requirements of the latest revision of Rolls Royce NMSB TrentXWB-72-AL055.**

l. After you have made sure that the data is correct write your name or AY-number to the Checked By -field.

5.Refresh report by selecting "Refresh All" from "Data" -tab.
6. Select engine to examined.
7. Select Date of last flight to be examined. Most often date of today is to be selected unless, report will be made subsequently.
8. Refresh report by selecting *"Refresh All" from "Data" -tab.*
9. Make sure that all queries have been successfully loaded by opening "Data" -> "Queries & connections" before using any results.

Select Engine: [redacted] OH-LWG; E#1

Select Date of Last Flight: 11.6.2024

DD.MM.YYYY

Trent XWB-72-AL055 Single Engine Data Quantity Report

Engine Serial Number: [redacted]
Aircraft Registration: **OH-LWG**
Engine Position: **#1**

This Report is to be used when performing Rolls Royce NMSB Trent XWB-72-AL055 according to compliance method B.

Last 30 Flights of aircraft. (Flights when departure airport ≠ arrival airport)					Matching Reports	
Seq.	Flight Number	Route	Departure Time	Arrival Time	Cruise Report	Flight Summary-Short
1	AY1338	LHR - HEL	11.6.2024 17.39.00	11.6.2024 19.54.00	NOT FOUND	11.6.2024 19.59.19
2	AY1337	HEL - LHR	11.6.2024 13.12.00	11.6.2024 15.35.00	11.6.2024 14.20.42	NOT FOUND
3	AY122	DEL - HEL	11.6.2024 2.38.00	11.6.2024 10.49.00	11.6.2024 9.22.59	11.6.2024 10.55.30
4	AY121	HEL - DEL	10.6.2024 15.46.00	10.6.2024 23.32.00	10.6.2024 23.03.15	NOT FOUND
5	AY142	BKK - HEL	10.6.2024 0.35.00	10.6.2024 11.48.00	10.6.2024 10.56.03	NOT FOUND
6	AY141	HEL - BKK	9.6.2024 11.25.00	9.6.2024 22.14.00	9.6.2024 21.43.35	9.6.2024 22.19.15
7	AY20	DFW - HEL	8.6.2024 22.09.00	9.6.2024 7.20.00	9.6.2024 5.17.39	NOT FOUND
8	AY19	HEL - DFW	8.6.2024 9.56.00	8.6.2024 19.37.00	8.6.2024 16.06.20	8.6.2024 19.44.49
9	AY20	DFW - HEL	7.6.2024 22.16.00	8.6.2024 7.42.00	8.6.2024 4.23.33	NOT FOUND
10	AY19	HEL - DFW	7.6.2024 10.05.00	7.6.2024 19.35.00	7.6.2024 17.46.01	7.6.2024 19.40.05
11	AY132	SIN - HEL	6.6.2024 14.14.00	7.6.2024 2.51.00	7.6.2024 2.13.10	NOT FOUND
12	AY131	HEL - SIN	5.6.2024 21.41.00	6.6.2024 10.22.00	6.6.2024 8.23.00	NOT FOUND
13	AY122	DEL - HEL	5.6.2024 2.30.00	5.6.2024 10.58.00	5.6.2024 10.10.50	5.6.2024 11.03.10
14	AY121	HEL - DEL	4.6.2024 15.42.00	4.6.2024 23.03.00	4.6.2024 22.05.58	4.6.2024 23.21.33
15	AY132	SIN - HEL	3.6.2024 13.54.00	4.6.2024 2.44.00	4.6.2024 2.10.42	NOT FOUND
16	AY131	HEL - SIN	2.6.2024 22.10.00	3.6.2024 10.35.00	3.6.2024 8.38.35	NOT FOUND
17	AY1338	LHR - HEL	2.6.2024 18.01.00	2.6.2024 20.22.00	NOT FOUND	2.6.2024 20.27.21
18	AY1337	HEL - LHR	2.6.2024 13.45.00	2.6.2024 16.08.00	NOT FOUND	NOT FOUND
19	AY122	DEL - HEL	2.6.2024 2.27.00	2.6.2024 10.55.00	2.6.2024 7.58.04	NOT FOUND
20	AY121	HEL - DEL	1.6.2024 15.44.00	1.6.2024 23.02.00	1.6.2024 22.20.12	1.6.2024 23.13.54
21	AY2	LAX - HEL	1.6.2024 3.05.00	1.6.2024 13.11.00	1.6.2024 10.00.24	NOT FOUND
22	AY1	HEL - LAX	31.5.2024 14.22.00	1.6.2024 0.39.00	31.5.2024 20.52.59	NOT FOUND
23	AY122	DEL - HEL	31.5.2024 2.45.00	31.5.2024 11.12.00	31.5.2024 9.29.56	NOT FOUND
24	AY121	HEL - DEL	30.5.2024 15.39.00	30.5.2024 22.51.00	30.5.2024 22.01.40	NOT FOUND
25	AY1332	LHR - HEL	30.5.2024 10.04.00	30.5.2024 12.26.00	30.5.2024 11.48.27	30.5.2024 12.31.08
26	AY1331	HEL - LHR	30.5.2024 5.15.00	30.5.2024 7.42.00	NOT FOUND	NOT FOUND
27	AY132	SIN - HEL	29.5.2024 14.16.00	30.5.2024 2.56.00	30.5.2024 1.08.53	NOT FOUND
28	AY131	HEL - SIN	28.5.2024 21.44.00	29.5.2024 10.01.00	29.5.2024 8.17.05	NOT FOUND
29	AY100	HKG - HEL	27.5.2024 12.58.00	28.5.2024 1.54.00	28.5.2024 0.25.16	NOT FOUND
30	AY99	HEL - HKG	26.5.2024 21.56.00	27.5.2024 9.22.00	27.5.2024 8.12.04	NOT FOUND
				Total:	26	10
				Result:	PASS	

Minimum 15 matching reports are required from either report type for signing NMSB as completed for the specific engine.

Checked by (Name and Date):

Setup | Single Engine Report | Fleet Overview Rep

Figure 6. Single Engine Report, Engine serial numbers censored.

3.3 Saving a Report

Caution: Do not save the report with the **Save** or **Save As** functions, since data files are not stored with the table, and it won't work when opened on another computer.

a. From the bottom sheet selection, open **Single Engine Report** or **Fleet Overview Report** depending on which you wish to save.

b. From the top left corner click **File** and from the menu that comes into view click **Print**.

c. From the printer dropdown list select **Microsoft Print to PDF**.

d. For setting select **Print Active Sheets, Portrait Orientation**, **A4**, **Normal Margins** and **Fit Sheet on One Page**.

e. Click **Print** and select saving location for the report.

f. As Filename copy one of the following filenames and insert the engine serial number and date:

   SSSSS_YYYY.MM.DD_72-AL055_SingleEngineReport
   YYYY.MM.DD_72-AL055_FleetOverviewReport

g. Click **Save**.

4 Signing Process

a. If you are using Single Engine Report, go to step 4c, otherwise continue to this step: Create a new folder to the location specified in the maintenance event. Name it the same as the report PDF file.

b. Move the utilization file from AMOS, data files from RR Care and Fleet Overview Report PDF to the created folder. Go to step 4d.

c. Move the created Single Engine Report PDF to the folder stated in the maintenance event.

d. Make sure that the aircraft does not have open vibration alerts according to 72-AL055.

e. Report back the maintenance event according to AMOS instructions.

Caution: Report back time must be selected that is between the last flight of the report data and the next flight of the engine. This is important so that engine flight cycle counting restarts during the correct ground time.